

APPENDIX B

ASSESSMENT OF BLUE ROCKFISH (*Sebastes mystinus*) IN CALIFORNIA

STAR PANEL

May 21, 2007

MODEL SELECTION - Comparison of ASPIC and SS2

Initial attempts to develop an SS2 model of Blue rockfish were inconclusive. The model was set up as a stock reduction analysis, i.e., driven by a stock-recruitment relationship with no variability (recruit devs were turned off). The model did not search the parameter space effectively, probably due to combined properties of a flat response surface, and nearness of the maximum likelihood value to the region where a “crash penalty” is invoked. The “crash penalty” results from parameter sets that cause catches to exceed the model’s estimate of fish available to be caught.

Aside from the fact that we resorted to the ASPIC production model because we were unable to obtain a properly functioning SS2 model (which is probably not a fault of the SS2 model), there are also some comparative virtues in the production model approach. The following discussion relates to a data-poor specification of a SS2 model as attempted for blue rockfish, and does not necessarily reflect properties of other SS2 implementations that could be attempted in more data-rich situations.

Catch uncertainty: The magnitude of the catch is a major uncertainty in the case of blue rockfish, even to the extent that it is the basis of our proposed decision table, which will be discussed further in this document. SS2 makes the assumption that catch is known without error, which may be an important model mis-specification in this context. In contrast, ASPIC emphasizes fitting the catch series, which is especially appropriate in the case of uncertain catches. In this regard, ASPIC may theoretically be the better specified model, but in practice, sensitivity to this aspect of model specification is not known, but is evaluated here.

Model rigidity and the virtual population constraint: A commonly encountered problem in stock reduction models is the SS2 “crash penalty” which is invoked when modeled abundance of available fish is insufficiently large to support the observed subsequent removals. We will call this the virtual population (VP) constraint, in that the lower bound of estimated abundance is constrained by a minimum virtual population size related to the sum of subsequent observed catches (i.e., the population could not have been smaller than the amount of fish we actually took from it). Importantly, in the absence of the “crash penalty” in SS2, or some other model specification to deal with this problem, the VP constraint can exist independently of the likelihood function, preventing an efficient search of the likelihood response surface for a maximum value. In some

cases, the “theoretical” maximum likelihood value can lie on the prohibited side of the VP constraint (A. MacCall, personal observation), resulting in severe estimation difficulties.

Although production models can also encounter the VP constraint, the detailed internal demographic structure of SS2 can make stock reduction model implementations prone to estimation problems associated with this constraint, e.g., in the 2005 cowcod assessment (Piner et al. 2005). In reality, fishery selectivity curves tend to adapt to the demographics of available fish, so that when large fish become rare, full selectivity often shifts to a smaller size. Also, geographic variability in growth curves can produce catches with size compositions that are difficult to portray in a single homogeneous SS2 representation. For blue rockfish we lack the data to model these fishery and resource behaviors in SS2, and must settle for an overly rigid treatment of time and space-invariant growth and selectivity curves. In contrast, the less explicit ASPIC model does not attempt to account for such detailed demographic differences among catch compositions from various fishery segments, which may in some ways be less realistic, but also makes it less vulnerable to estimation problems associated with the VP constraint.

Unknown demographics: Both ASPIC and SS2, in the present specification as a stock reduction analysis, model the same fundamental process of a deterministic production function based on resource abundance, and simple periodic removals of catch. ASPIC assumes that the catch and abundance index reflect similar but unspecified demographics to the extent that the absolute reduction in abundance is proportional to catch. In contrast, SS2 contains a detailed age and size-structured demographic model of the resource and individual fishery segments, which is necessarily over-simplified in the data-poor case of blue rockfish. Important demographic parameters, such as the natural mortality rate, are unknown and cannot be estimated in the present context, so values are assumed (based on conventional rules-of-thumb) but are treated as known constants in SS2. In contrast, a production model does not require some of these assumptions.

Management reference points: The detailed demographic model in SS2 allows calculation of management reference values, such as SPR that are used in the management of fishing mortality rates west coast groundfish. ASPIC produces a different but analogous measure of fishing mortality rate, relative to the F_{msy} specified by the underlying production function (logistic or generalized). It can be argued that the F_{msy} reference point from ASPIC is at least based on blue rockfish data, whereas the west coast groundfish proxy reference point of $SPR=50\%$ is a generic value for all rockfish, and is not based on blue rockfish data at all.

Beverton-Holt steepness: Steepness, as currently considered in assessment of west coast groundfish, is a property of the Beverton-Holt SRR, which itself is a conventionally assumed rather than objectively determined specification of groundfish models. Other stock-recruitment relationships have been considered in a meta-analytic context (Dorn 2002), and have been shown to be statistically indistinguishable. (It is interesting to note that the difference between a Beverton-Holt SRR and a Ricker SRR becomes

progressively smaller as steepness declines, and the currently favored prior distribution of steepness is even lower than previously found by Dorn, and is extraordinarily low in comparison to other world fisheries.) The implicit stock-recruitment relationship underlying an ASPIC model fit would almost certainly be statistically indistinguishable from any SRR fit to blue rockfish by an SS2 model. Consideration of alternative values of steepness (including the currently favored steepness prior distribution) has an analog in exponents used in the generalized production model. However, there is no simple relationship between ASPIC and SS2 that can be compared quantitatively because each SRR is no longer invariant when it is considered in the demographic context of the alternative model. Approximate comparisons could be attempted, but time has not allowed this to be explored. In this regard, experience has shown that the logistic case of ASPIC is robust (Prager, ASPIC documentation).

ASPIC 5.10.3

The available data were well-suited for the use of a production model. We used a stock production model incorporating covariates (ASPIC_Version 5.10.3, May 2007) (Prager 1994) that was available in NOAA's toolbox: <http://nft.nefsc.noaa.gov/>. Where version 3 would estimate parameters of a non-equilibrium solution to a Schaefer logistic production model, version 5 has the ability to fit the Pella-Tomlinson generalized model in the revised parameterization of Fletcher (Prager 2004). Ludwig and Walters (1985) concluded that "simple production models should often be used in stock assessments based on catch/effort data, even when more realistic and structurally correct models are available to the analyst."

The estimated parameters consist of K (the stock's carrying capacity), MSY , ratio of B_1/K (beginning biomass relative to K), and a catchability coefficient for each abundance index series (q_i) for the Schaefer logistic model. When parameter B_1/K is estimated freely, the estimated biomasses are unrealistically small relative to the unfished state. Accordingly we use a value of B_1/K that was fixed at a value of 0.77, which is plausible, given the lack of a targeted fishery before 1969. We explored a range of values (0.1, 0.2, ... 1.0) and found that values from 0.77 and 1.0 did not alter the ending results (Table 1). Punt (1990) determined that pre-specifying B_1 substantially improved the performance of a production model in a case like this.

Table 1. Exploration of beginning values for B_1/K for the logistic (Shaefer) surplus-production model (ASPIC_v5.10.3). Average catches ($(\text{original estimated} + \text{fishermen recommended})/2$) were used for these runs.

	current biomass	unfished biomass	% unfished biomass	MSY
$B_1/K = 0.77$	1904	3999	0.48	700
$B_1/K = 0.78$	1905	3996	0.48	700
$B_1/K = 0.79$	1904	3998	0.48	700
$B_1/K = 0.8$	1902	3992	0.48	700
$B_1/K = 0.9$	1908	3986	0.48	699
$B_1/K = 1.0$	1907	3981	0.48	699

Base Model

The base model uses an intermediate catch series from 1969 to 2006, which is the average of the fishermen-supplied estimates and the documented landings from various sources. The CPUE series is based on RecFIN data from 1980 to 2006, with some missing years. This index was originally based on numbers of fish caught per angler hour, rather than biomass, and even though Prager and Goodyear (2001) found that production model performance was “surprisingly robust” to use of mixed-metric data, we multiplied each index by the average annual weight to base it on biomass. B_1/K is fixed at 0.77. Detailed results are given in the attached ASPIC output. Current biomass is estimated to be at 1905 mtons, which is 48 percent of unfished abundance. MSY is estimated to be 700 mtons, compared with a 2006 total catch of 341.5 mtons.

Baseline model results of fits and estimated F using average catches.
Number of bootstrap trials = 500.

Year	Obs CPUE	Est. CPUE	Est. F	Obs yield	Model yield	Resid in log scale
1969		0.99	0.070	223.00	223.00	0.000
1970		1.05	0.072	244.00	244.00	0.000
1971		1.06	0.097	334.00	334.00	0.000
1972		1.06	0.116	395.00	395.00	0.000
1973		1.01	0.197	643.00	643.00	0.000
1974		0.93	0.276	829.00	829.00	0.000
1975		0.83	0.353	947.00	947.00	0.000
1976		0.78	0.262	662.00	662.00	0.000
1977		0.76	0.320	786.00	786.00	0.000
1978		0.74	0.285	683.00	683.00	0.000
1979		0.72	0.353	818.00	818.00	0.000
1980	0.51	0.67	0.403	870.00	870.00	0.272
1981	0.76	0.59	0.545	1034.00	1034.00	-0.258
1982	0.80	0.49	0.605	959.00	959.00	-0.488
1983	0.51	0.40	0.705	909.00	909.00	-0.244
1984	0.40	0.32	0.745	766.00	766.00	-0.228
1985	0.34	0.25	0.796	649.00	649.00	-0.297
1986	0.07	0.23	0.560	408.00	408.00	1.171
1987	0.14	0.22	0.634	451.00	451.00	0.453
1988	0.11	0.20	0.683	449.00	449.00	0.616
1989	0.09	0.20	0.519	336.00	336.00	0.802
1990		0.23	0.387	285.00	285.00	0.000
1991		0.29	0.273	252.00	252.00	0.000
1992		0.30	0.697	672.00	672.00	0.000
1993	0.18	0.21	1.153	776.00	776.00	0.147
1994	0.15	0.14	0.829	375.00	375.00	-0.068
1995	0.30	0.13	0.611	251.00	251.00	-0.858
1996	0.23	0.14	0.464	208.00	208.00	-0.504
1997		0.14	0.820	360.00	360.00	0.000
1998		0.11	0.818	297.00	297.00	0.000
1999	0.24	0.10	0.741	234.00	234.00	-0.897
2000	0.10	0.10	0.517	166.00	166.00	-0.005
2001	0.06	0.12	0.340	135.00	135.00	0.717
2002	0.34	0.16	0.314	167.00	167.00	-0.726
2003	0.19	0.22	0.329	229.00	229.00	0.126
2004	0.32	0.29	0.173	164.00	164.00	-0.086
2005	0.34	0.41	0.137	184.00	184.00	0.199
2006	0.46	0.54	0.197	341.00	341.00	0.156

**Baseline model results for F/Fmsy and B/Bmsy using average catches.
Number of bootstrap trials = 500.**

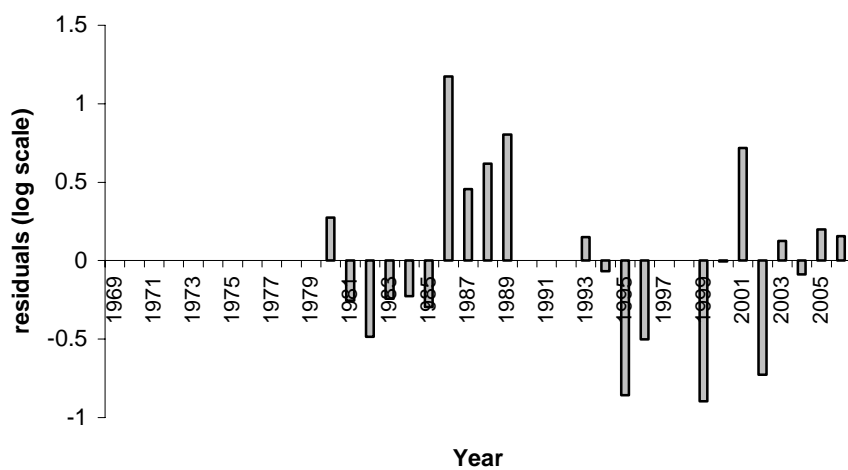
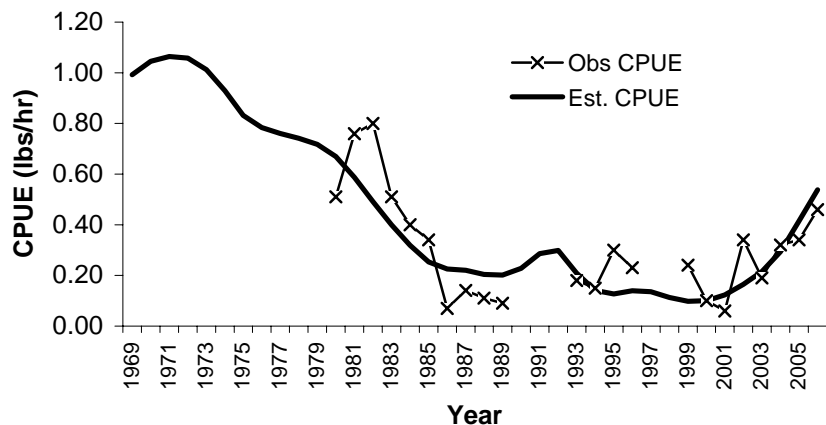
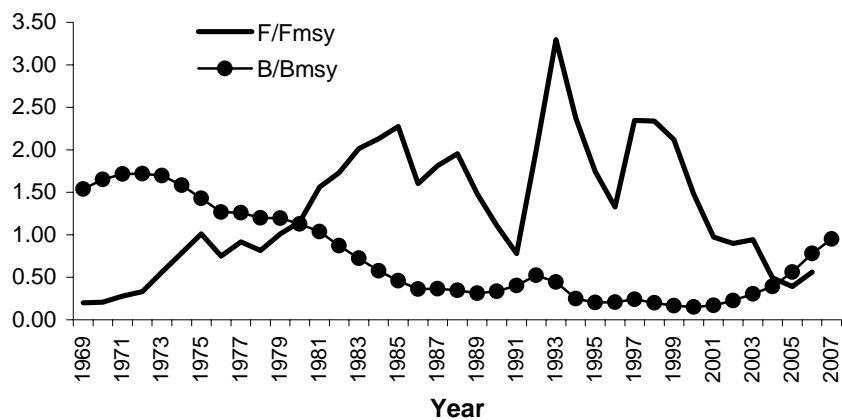
ESTIMATED POPULATION TRAJECTORY

Year	Est. Total F Mort	Est. Beg. Biomass	Est. Avg Bio	Obs Tot Yield	Model Tot Yield	Est. Surplus Prod	F/Fmsy	B/Bmsy
1969	0.07	3082.00	3203.00	223.00	223.00	446.80	0.20	1.54
1970	0.072	3306.00	3375.00	244.00	244.00	370.10	0.21	1.65
1971	0.097	3432.00	3436.00	334.00	334.00	340.50	0.28	1.72
1972	0.116	3439.00	3414.00	395.00	395.00	351.00	0.33	1.72
1973	0.197	3395.00	3270.00	643.00	643.00	417.90	0.56	1.70
1974	0.276	3170.00	3001.00	829.00	829.00	523.90	0.79	1.58
1975	0.353	2864.00	2683.00	947.00	947.00	617.00	1.01	1.43
1976	0.262	2534.00	2529.00	662.00	662.00	651.20	0.75	1.27
1977	0.32	2524.00	2457.00	786.00	786.00	663.20	0.91	1.26
1978	0.285	2401.00	2395.00	683.00	683.00	672.70	0.82	1.20
1979	0.353	2391.00	2317.00	818.00	818.00	682.10	1.01	1.19
1980	0.403	2255.00	2160.00	870.00	870.00	694.90	1.15	1.13
1981	0.545	2080.00	1896.00	1034.00	1034.00	696.20	1.56	1.04
1982	0.605	1742.00	1585.00	959.00	959.00	668.30	1.73	0.87
1983	0.704	1451.00	1290.00	909.00	909.00	610.10	2.02	0.73
1984	0.745	1152.00	1028.00	766.00	766.00	533.50	2.13	0.58
1985	0.796	919.60	815.70	649.00	649.00	453.60	2.28	0.46
1986	0.56	724.20	728.70	408.00	408.00	416.80	1.60	0.36
1987	0.634	733.00	711.30	451.00	451.00	408.90	1.81	0.37
1988	0.683	690.90	657.30	449.00	449.00	384.10	1.95	0.35
1989	0.519	626.00	648.00	336.00	336.00	379.70	1.48	0.31
1990	0.387	669.70	736.60	285.00	285.00	420.00	1.11	0.33
1991	0.273	804.70	924.80	252.00	252.00	496.40	0.78	0.40
1992	0.697	1049.00	964.30	672.00	672.00	511.50	1.99	0.52
1993	1.153	888.50	673.10	776.00	776.00	389.30	3.30	0.44
1994	0.829	501.90	452.30	375.00	375.00	280.40	2.37	0.25
1995	0.611	407.30	410.60	251.00	251.00	257.70	1.75	0.20
1996	0.464	413.90	448.70	208.00	208.00	278.50	1.33	0.21
1997	0.82	484.50	439.10	360.00	360.00	273.20	2.35	0.24
1998	0.817	397.70	363.30	297.00	297.00	230.90	2.34	0.20
1999	0.741	331.60	316.00	234.00	234.00	203.50	2.12	0.17
2000	0.517	301.10	321.10	166.00	166.00	206.50	1.48	0.15
2001	0.34	341.60	396.90	135.00	135.00	249.80	0.97	0.17
2002	0.314	456.50	531.30	167.00	167.00	321.90	0.90	0.23
2003	0.329	611.30	695.70	229.00	229.00	401.50	0.94	0.31
2004	0.173	783.80	948.50	164.00	164.00	504.40	0.49	0.39
2005	0.137	1124.00	1339.00	184.00	184.00	620.30	0.39	0.56
2006	0.196	1560.00	1736.00	341.00	341.00	685.70	0.56	0.78
2007		1905.00						0.95

Baseline model reference point results using average catches. Number of bootstrap trials = 500.
CV from the bootstrap distribution = 0.32

	Point Est.	Est. bias in Pt. Est.	Est. rel. bias	Bias-corrected Approximate CLs				Inter-quartile range	Rel. IQ range
				80% L	80% U	50% L	50% U		
B1/K	0.77	0.00	0.00%	0.77	0.77	0.77	0.77	0.00	0.000
K	4003.00	256.10	6.40%	3856.00	4972.00	3881.00	4271.00	389.30	0.097
q(1)	0.00	0.00	-2.31%	0.00	0.00	0.00	0.00	0.00	0.277
MSY	699.80	-9.26	-1.32%	651.70	707.50	686.10	706.10	20.05	0.029
Ye(2007)	698.10	-53.11	-7.61%	682.80	711.00	699.30	708.60	9.30	0.013
Y.@Fmsy	666.10	-21.08	-3.16%	464.40	928.30	562.40	815.90	253.60	0.381
Bmsy	2002.00	128.00	6.40%	1928.00	2486.00	1941.00	2135.00	194.60	0.097
Fmsy	0.35	-0.02	-4.79%	0.26	0.37	0.32	0.36	0.04	0.120
fmsy(1)	1129.00	7.13	0.63%	1031.00	1480.00	1099.00	1359.00	259.40	0.230
B./Bmsy	0.95	-0.02	-2.42%	0.66	1.31	0.79	1.14	0.35	0.364
F./Fmsy	0.56	0.07	11.88%	0.39	0.82	0.46	0.67	0.21	0.373
Ye./MSY	1.00	-0.06	-6.25%	0.99	1.00	1.00	1.00	0.00	0.001

Figures for baseline model results of F/F_{msy} , B/B_{msy} , fit to the CPUE index and residuals. Actual values represented in previous tables.



Sensitivity Analysis

Three different catch series were considered in this assessment. First, the original estimates that were provided from various sources (ie. RecFIN, CALCOM). Secondly, recommended catches that were received during a Data Workshop with fishermen that have a history in the blue rockfish fishery (details in the draft document). Lastly, the average of the two series that were used in the baseline model. Considering there is uncertainty in all of these estimates, we ran sensitivities on the original estimates and the fishermen's recommended catch series. Table ? provides the catch scenarios used in the baseline model and the described sensitivity analysis.

Catch streams considered in this assessment. Estimated catches came from RecFIN and CALCOM data sources. Fishermen's catches came from recommendations of fishermen that attended the Data Workshop for blue rockfish. Average catches is the average between the two and were used in the baseline model.

Year	<u>Estimated Catches</u>				<u>Fishermen's recommended Catches</u>				<u>Average Catches</u>			
	Recreational	Comm - Hook & Line	Comm - Gillnet	total	Recreational	Comm - Hook & Line	Comm - Gillnet	total	Recreational	Comm - Hook & Line	Comm - Gillnet	total
5 yr avg	388.2	15.3	28.2	431.7	103.6	104.4	95.6	303.6	245.9	59.8	61.9	367.6
1969	128.8	11.0	3.5	143.3	103.6	159.0	41.0	303.6	116.2	85.0	22.2	223.4
1970	164.9	14.0	4.5	183.3	103.6	159.2	40.8	303.6	134.2	86.6	22.6	243.4
1971	326.9	10.6	26.0	363.5	103.6	68.1	131.9	303.6	215.2	39.3	79.0	333.5
1972	436.6	16.7	32.2	485.5	103.6	79.1	120.9	303.6	270.1	47.9	76.5	394.5
1973	884.1	24.3	74.7	983.1	103.6	56.4	143.6	303.6	493.8	40.3	109.1	643.3
1974	1149.1	22.2	106.5	1277.7	129.4	53.3	196.7	379.4	639.3	37.7	151.6	828.6
1975	1294.3	25.7	119.2	1439.3	155.3	68.8	231.2	455.3	724.8	47.2	175.2	947.3
1976	644.3	33.0	39.1	716.5	207.1	211.4	188.6	607.1	425.7	122.2	113.8	661.8
1977	730.8	29.7	52.2	812.7	258.9	220.2	279.8	758.9	494.9	124.9	166.0	785.8
1978	409.3	29.1	16.8	455.1	310.7	456.8	143.2	910.7	360.0	242.9	80.0	682.9
1979	515.1	44.3	13.3	572.8	362.5	560.8	139.2	1062.5	438.8	302.6	76.3	817.6
1980	487.0	49.8	2.3	539.1	400.0	400.0	400.0	1200.0	443.5	224.9	201.1	869.6
1981	826.5	65.7	1.2	893.4	400.0	375.0	400.0	1175.0	613.2	220.3	200.6	1034.2
1982	707.7	60.6	0.5	768.8	400.0	350.0	400.0	1150.0	553.9	205.3	200.2	959.4
1983	661.2	55.3	0.8	717.4	400.0	325.0	375.0	1100.0	530.6	190.2	187.9	908.7
1984	469.2	11.5	1.3	482.0	400.0	300.0	350.0	1050.0	434.6	155.8	175.7	766.0
1985	261.7	39.9	134.5	436.1	261.7	275.0	325.0	861.7	261.7	157.5	229.7	648.9
1986	124.7	3.0	12.8	140.6	124.7	250.0	300.0	674.7	124.7	126.5	156.4	407.7
1987	258.9	7.8	0.4	267.2	258.9	225.0	150.0	633.9	258.9	116.4	75.2	450.6
1988	307.1	7.7	0.1	314.9	307.1	200.0	75.0	582.1	307.1	103.9	37.6	448.5
1989	245.0	17.4	14.1	276.4	245.0	150.0	0.0	395.0	245.0	83.7	7.0	335.7
1990	221.1	26.9	1.5	249.6	221.1	100.0	0.0	321.1	221.1	63.5	0.8	285.3
1991	183.7	35.4	1.4	220.5	183.7	100.0	0.0	283.7	183.7	67.7	0.7	252.1
1992	490.3	181.4	0.0	671.8	490.3	181.4	0.0	671.8	490.3	181.4	0.0	671.8
1993	643.0	134.3	0.3	777.6	643.0	134.3	0.0	777.3	643.0	134.3	0.2	777.5
1994	305.8	69.2	0.0	375.1	305.8	69.2	0.0	375.0	305.8	69.2	0.0	375.1
1995	216.3	34.7	0.0	251.0	216.3	34.7	0.0	251.0	216.3	34.7	0.0	251.0
1996	164.0	44.0	0.1	208.1	164.0	44.0	0.0	208.0	164.0	44.0	0.0	208.1
1997	296.1	63.7	0.0	359.7	296.1	63.7	0.0	359.7	296.1	63.7	0.0	359.7
1998	249.4	47.9	0.0	297.3	249.4	47.9	0.0	297.3	249.4	47.9	0.0	297.3
1999	198.6	35.7	0.1	234.4	198.6	35.7	0.0	234.3	198.6	35.7	0.0	234.3
2000	150.7	15.6	0.0	166.3	150.7	15.6	0.0	166.3	150.7	15.6	0.0	166.3
2001	115.6	19.7	0.0	135.3	115.6	19.7	0.0	135.3	115.6	19.7	0.0	135.3
2002	148.8	18.5	0.0	167.4	148.8	18.5	0.0	167.4	148.8	18.5	0.0	167.4
2003	219.9	9.2	0.0	229.1	219.9	9.2	0.0	229.1	219.9	9.2	0.0	229.1
2004	149.9	14.8	0.0	164.6	149.9	14.8	0.0	164.6	149.9	14.8	0.0	164.6
2005	162.9	21.7	0.0	184.6	162.9	21.7	0.0	184.6	162.9	21.7	0.0	184.6
2006	319.6	21.9	0.0	341.4	319.6	21.9	0.0	341.4	319.6	21.9	0.0	341.4

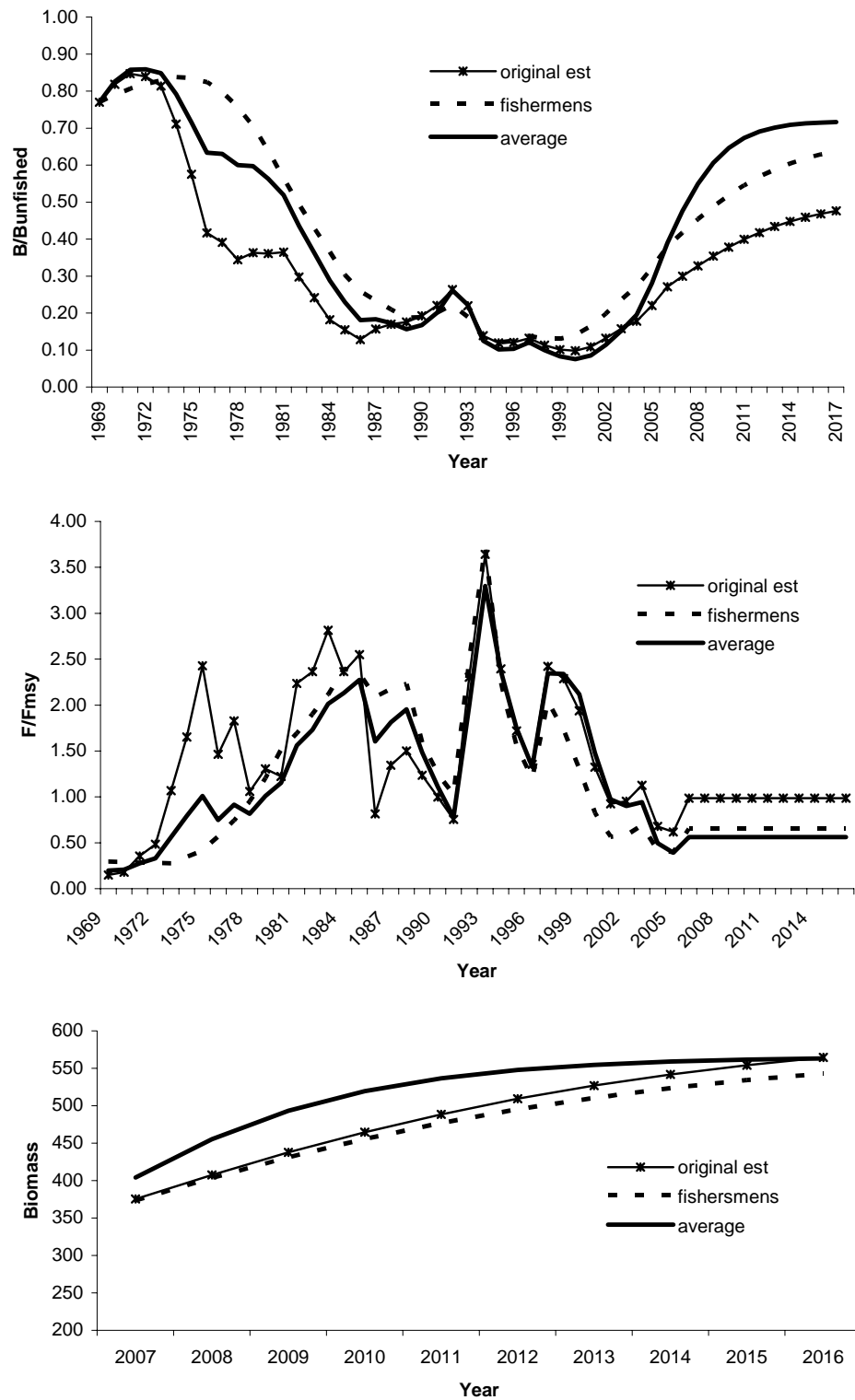
First, for each catch scenario, we attempted to fit the Pella-Tomlinson generalized model. We initially scanned values of the model shape that produced the best fit and then used that value to fit the model. In all three scenarios, it was noted that the generalized fit was not a better than the logistic fit, so the sensitivity analysis is now limited to the results of the logistic (Shaefer) model.

Reference points calculated from the three catch series sensitivity analysis. The base model uses the average catches of the estimated and fishermen recommended catches.

		Schaefer Logistic		
		Estimated	Fishermens	* Average
B1/K	Starting relative biomass	0.77	0.77	0.77
MSY	Maximum sustainable yield	607	659	700
K	Maximum population size	5281	7483	4003
phi	Shape of production curve	0.50	0.50	0.50
B _{msy}	Stock biomass given MSY	2641	3742	2002
Yield(F _{msy})	Yield available at F _{msy} in 2007	364	550	666
B/B _{msy}	B ₂₀₀₇ /B _{msy} (as proportion on MSY)	0.60	0.83	0.95
B/B _{unfished}	(B ₂₀₀₇ /B _{msy}) / 2	0.30	0.42	0.48
B ₂₀₀₇ /K	<i>Depletion</i>	0.30	0.42	0.48
Yield	Equilibrium yield available in 2007	510	641	698
	as proportion of MSY	0.84	0.97	1.00
F _{msy}	Fishing mortality given MSY	0.23	0.18	0.35
F/F _{msy}	F ₂₀₀₆ /F _{msy}	0.98	0.65	0.56
F _{msy} /F	F _{msy} /F ₂₀₀₆	1.02	1.54	1.78
B ₂₀₀₇	Beginning biomass in 2007	1583	3123	1905
C ₂₀₀₆	Total catch in 2006	342	342	342
R2	CPUE	0.42	0.60	0.63
CV	bootstrapped	0.55	0.41	0.32

* Baseline model - Shaefer logistic surplus-production model with average catch series.

Figures comparing the biomass, fishing mortality and projections from three catch streams: original estimates, fishermen recommended changes to those estimates, and an average (base model) of the two catch streams.



The Mop-Up STAR panel (October 2007, Seattle WA) requested that a comparison be made between the two base models in ASPIC and SS2. The following is a comparison of relative depletion (top) and biomass between ASPIC (exploitable biomass) and SS2 (spawning output), (bottom).

